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Framework for Migrating Telecom Services to Software Defined Networking, and Network Function Virtualization

2017 TECHNICAL REPORT

Framework for Migrating Telecom Services to Software Defined Networking, and Network Function Virtualization

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Abstract

This research is designed to discover applicable standards, guidelines, and recommended practices needed to minimize the risk of migrating telecom services to a Software Defined Network/Network Function Virtualization (SDN/NFV) environment. This technical update focuses attention on the current work in several standards development organizations (SDOs) and supporting study committees (SCs) developing open systems specifications for SDN and NFV that have strong relevance to electric power utility telecom operations. The results of this study established an initial framework strategy to migrate local telecom services to telecom services offered by SDN/NFV solutions. As this framework matures, utilities will have the information needed to tailor the specifications to reflect their telecom operational constraints in new contracting initiatives. The framework is designed to address four topics:

- Benefits derived from SDN/NFV telecom operations with emphasis on selected telecom applications.
- Technical issues that must be addressed in the telecom migration strategy that can be tailored for utility 5- and 10-year roll-out plans.
- Utility expertise required to deploy, operate, and maintain secure SDN/NFV operations.
- Requirements that should be included, with some tailoring, in the service agreements with the providers of SDN/NFV services.

Keywords
Software defined network
Network function virtualization
Telecom services
Standards development organizations
Open systems specifications

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Product Title: Framework for Migrating Telecom Services to Software Defined Networking, and Network Function Virtualization

PRIMARY AUDIENCE: Utility stakeholders and senior managers responsible for committing resources to implement a Software Defined Network/Network Function Virtualization (SDN/NFV) migration strategy.

SECONDARY AUDIENCE: Organizational units that will oversee the implementation and deployment of telecom services in the SDN/NFV environment.

KEY RESEARCH QUESTION

This research is designed to discover applicable standards, guidelines, and recommended practices needed to minimize the risk of migrating telecom services to an SDN/NFV environment.

RESEARCH OVERVIEW

Implementing this research project required tracking and active participation in multiple standards development organization working groups and supporting study committees. Particular attention was given to developing use cases relevant to utility telecom operations and assessment of the potential impact on performance and reliability of SDN/NFV services.

KEY FINDINGS

Recognizing this work as part of a multi-phased project, the key findings described are intended to establish a framework for the next phase of the project. A brief summary of the projects mentioned in the following list are described in the Technical Update Report.

- The reference architecture for deploying telecom services is well-understood. The best description of these architectures is documented in several European Telecommunication Standard Institute (ETSI) documents. At the high-level there is excellent alignment between the ETSI descriptions and those found in other specifications, such as NIST and Open Network Foundation (ONF) documents.
- How best to deploy such services as middleware is under active discussion within the IEEE P1930.1. Peer review of several middleware deployment concepts has summarized the advantages and disadvantages related to performance and reliability.
- Security to protect sensitive data in transit and at rest is under active discussion within IEEE P1915.1. EPRI's research project produced two utility use cases for peer review by P1915.1 members, which has resulted in wide acceptance of the use case template and supporting model-based system engineering (MBSE) models described in those use cases.
- Regarding sensitive data, EPRI's research project produced a classification guide that enumerates the sector categories for all data, the domain categories for sensitive data including the data classifications for governing authorities, and the protected data types for personal data. The classifications were derived from European Union (EU) General Data Protection Regulation (GDPR) and CypherCloud's "Global Guide to Data Protection Laws and Regulations." The classification guide and supporting MDSE model are under active peer review within IEEE P7002 and P7005 projects.

WHY THIS MATTERS

The value of this research is the identification and characterization of SND/NFV architectures, models, analytics, and requirements that can be used by the research project members to develop a risk-mitigated strategy to deploy and operate their telecom services in the SDN/NFV environment. The framework established to-date has provided the basis for developing concrete use cases, supporting models, and metrics that should be used by each utility to tailor their strategy.

HOW TO APPLY RESULTS

As the information resulting from this research project matures, the utility members should review the specifications and supporting data developed in these standards development organizations (SDOs) and study committees. EPRI member reviews should result in identification and recommendation of improvements to the products developed by the SDO and study committees. This feedback will ensure that the SDO and study committee products are easily mapped into your tailored deployment strategies.

LEARNING AND ENGAGEMENT OPPORTUNITIES

- There is information in the SDO and study committee products that should be shared with the utility's organizational units, including the stakeholder and advisors to senior managers who will approve and resource the selected deployment strategy. If those stakeholders and advisors flag a specification of concern, the EPRI project manager can submit the concern to the specification's authors.

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Section 1: Introduction

This technical update report (TuR) focuses attention on the current work in several standards development organizations (SDOs) and supporting study committees (SCs) who are developing open systems specifications for software defined networking (SDN) and network function virtualization (NFV) that have strong relevance to electric power utility telecom operations. The results of this 6-month study established an initial framework strategy to migrate local telecom services to telecom services offered by SDN/NFV solutions. As this framework matures, utilities will have the information needed to tailor the specifications to reflect their telecom operational constraints in new contracting initiatives. The framework is designed to address four topics:

1. Benefits derived from SDN/NFV telecom operations with emphasis on selected telecom applications.
2. Technical issues that must be addressed in the telecom migration strategy that can be tailored for utility 5- and 10-year roll-out plans.
3. Utility expertise required to deploy, operate, and maintain secure SDN/NFV operations.
4. Requirements that should be included, with some tailoring, in the service agreements with the providers of SDN/NFV services.

IEEE published "cloud computing application for smart grid – a survey" in 2013 that outlined the rich environment for leveraging cloud-based services [1]. This report was used to establish a basis for the research described in this technical update report. Additionally, this research made maximum use of the data addressed in several articles in IEEE Computer Society's Computing Edge publication in June 2016 [2] [3].

Next, a list of related SDO and SC initiatives was compiled and assessed. Data from these initiatives will be used to update future technical reports to capture their recommendations and to improve the framework. The list of initiatives is discussed in Section 3.

Lastly, given the framework from the open literature search and the expected results from the SDO and SC initiatives, a preliminary assessment of the relevance to utility telecom operations was performed to identify actionable tasks by the utility's responsible organization. This assessment is discussed in Section 4.

Section 2: Terminology

2.1 Definition of terms

2.1.1 Cloud computing

- The practice of using the Internet to process, manage and store data on remote network services
- Example: document collaboration tools
- Source [4]

2.1.2 Hybrid cloud

- Infrastructure composed of two or more distinct private, community, or public infrastructures that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability
- Source [5]

2.1.3 Privacy information

- Any recorded information about an identifiable individual.

2.2 Definition of acronyms

CIGRE	International Council on Large Electric Systems
IaaS	infrastructure as a service
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
NFV	network function virtualization
ONF	Open Network Foundation
PaaS	platform as a service
PAR	project authorization request
PACS	protection and control system
PoC	Proof-of-concept
PS	power systems
PSCC	Power System Communications and Cybersecurity
PSRC	Power System Relaying Committee
SDO	standards development organizations
SC	study committee
SDN	software defined networking
SME	Subject matter expert
SysML	system modeling language
TBD	to be defined
TF	task force
TR	technical report
WG	working group
WIP	work in progress

Section 3: Summary Description of Activities and Lessons Learned

3.1 Standards activities

Table 3-1 includes a description of several, but not all, active standard activities that potentially will contribute to a tailored utility's telecom migration strategy. For some of the activities the start date was 2015 or 2016, which reflects the project authorization request (PAR) start date of late 2015 or 2016. Most probably these activities started in 2016 and 2017 respectively. This late start will probably require an extension of the completion date. P1915.1 and PS P11 will have data to contribute to this framework in late 2017.

IEEE P1915.1 has an aggressive activity comprised of six work streams. Architecture is the primary focus now. Open Network Foundation (ONF) basic architecture (TR 521) shown in Figure 3-1 is one of the architectures under discussion. Figure 3-1, high-level overview, needs further clarification and detail based on use cases developed by WG P1915.1.

IEEE P1916.1 has an aggressive activity that begins with contributions of technical papers and presentations addressing SDN/NFV performance for single tenant and multi-tenant operation. Currently most papers are based on OpenStack performance but other mechanisms are expected soon [6] [7] [8] [9].

A particularly relevant paper in P1916.1 is a proof-of-concept (PoC) demonstrating the added value that dynamic SDN control, coordinated with a flexible cloud management approach, brings to telco operators and service providers [10]. The PoC use case described in this article leverages Ericsson's cloud management and orchestration platform and a stateful SDN framework developed at the University of Bologna.

The IEEE Power System Communication and Cybersecurity (PSCC) has approved a project (IEEE PS TF P11) to help develop a use case based on a survey of electric utility operators. Figure 3-2 shows a high-level SysML model used to focus attention on one of the important cyber threat vectors. If successful, this threat can interfere with, disrupt or disable the SDN resources, particularly those resources needed for telecommunications. A comprehensive analysis of security issues for cloud computing is addressed on application security, multi-tenancy, data security accessibility, Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Virtualization, etc. [11], Managing risks in a cloud ecosystem is

addressed in IEEE Computer Society's Computing Edge publication in March 2016 [12].

The other P191x.1 activities are not well understood at present. The expectation is that performance (P1916.1) and reliability (P1917.1) specifications should have some impact on the utility's telecom operation. As the work matures in 2017 the picture will be clarified. IEEE P2303 is focused on a hybrid architecture that has near term applications for utility telecom functions. WG P2303 needs use case applications to ensure they correctly articulate the technical specifications from the hybrid architecture and adaptive management requirements.

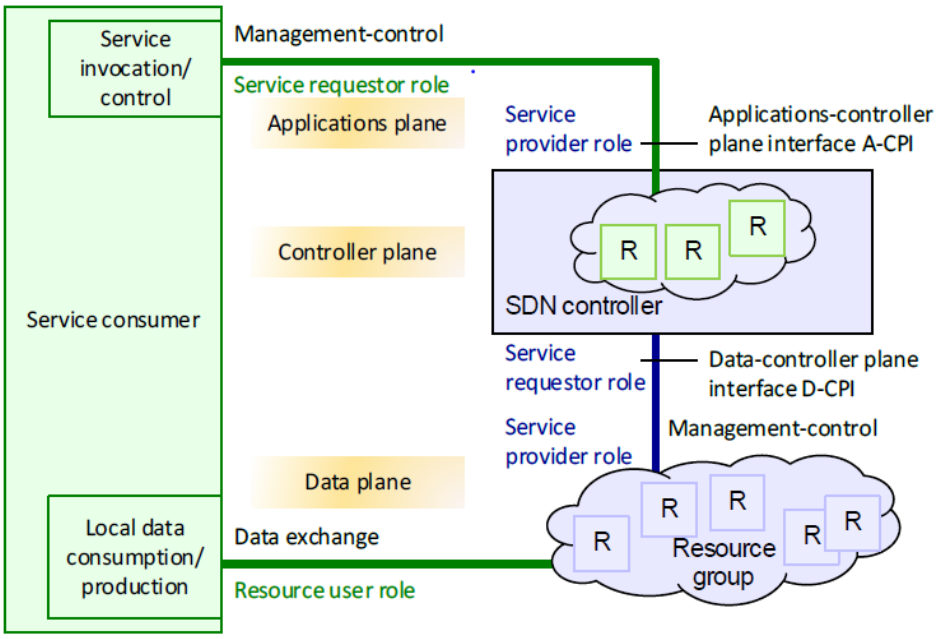

Figure 3-1
ONF basic architecture

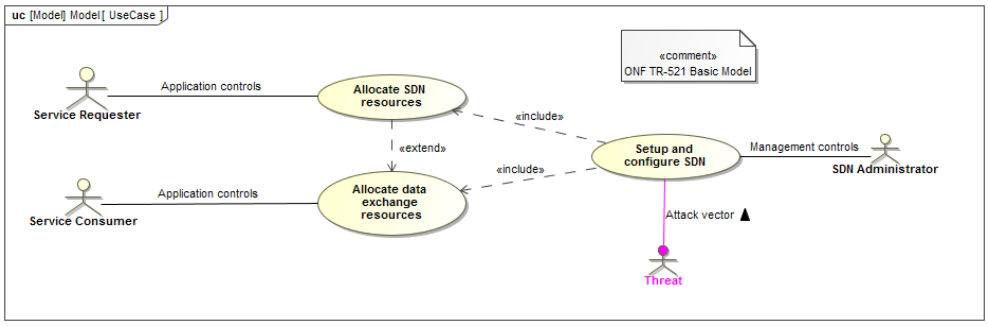

Figure 3-2
Cyber threat issue

Table 3-1
Standards Activity

ActivityID	Sponsor	Chair Person	Description/Scope	Period of Performance	Status
IEEE WG P1915.1	IEEE Communication Society	Anton Kaska	Specifies the security framework, models, analytics and requirements for SDN/NFV.	2015 – 2019 Monthly WebEx Collaboration meetings	WIP with 6 work streams 1. Architecture 2. Computational Infrastructure 3. Transport and Protocols 4. Physical Security 5. Policy Controls 6. Communication Infrastructure
IEEE WG P1916.1	IEEE Communication Society	Mohammad Asad Chaudhry	Specifies performance framework including characteristics, metrics, requirements, models, and use cases for SDN/NFV.	2015 – 2019 Monthly WebEx Collaboration meetings	WIP is collecting contributions from members
IEEE WG P1917.1	IEEE Communication Society	Peter Thermos	Specifies reliability framework, models, analytics, and requirements for SDN/NFV.	2015 – 2019 Monthly WebEx Collaboration meetings	Unknown
IEEE WG P1921.1	IEEE Communication Society	Christian Jacquenet	Specifies bootstrapping mechanisms for SDN architectures	2016-2020	Unknown, but probably started in 2017.
IEEE WG P1926.1 (Trial Use)	IEEE Communication Society	Jaafar M.H. Elmirghani	Specifies a functional architecture that supports the energy-efficient transmission and processing of large volumes of data, starting with processing nodes close to the data source, with significant processing resources provided at centralized data centers.	2016-2020	Unknown, but probably started in 2017.

Table 3-1 (continued)
Standards Activity

ActivityID	Sponsor	Chair Person	Description/Scope	Period of Performance	Status
IEEE WG P1927.1	IEEE Communication Society	Jaafar M.H. Elmirghani	Specifies an architecture for a service composed of distributed data centers interconnected by a network. It specifies the interfaces and the dynamic orchestration and management mechanisms for energy-efficient allocation of resources from data centers and network.	2016-2020	Unknown, but probably started in 2017.
IEEE WG 2303	IEEE Computer Society	Joel Fleck II	Adaptive management of cloud computing environments. Provides developers, providers, and partners of cloud computing ecosystems a foundational architecture and vocabulary for adaptive management systems needed to support the dynamic characteristics of cloud computing implementations. Includes a description of the core roles and sub-roles needed for an adaptive management environment, the fundamental components and information needed and communications needed to support adaptive management environments.	2015 – 2019 Monthly WebEx Collaboration meetings	Unknown

Table 3-1 (continued)
Standards Activity

ActivityID	Sponsor	Chair Person	Description/Scope	Period of Performance	Status
IEEE PS TF P11	IEEE PSCC Committee	T.W. Cease	Transition strategy to leverage cloud-based services.	2017 – 2019 WebEx collaboration meetings on demand Three face-to-face meetings per year	Start in May 2017.
IEEE PSRC WG H41	IEEE PSRC	Dennis Holstein	Update IEEE 1646-2004 "IEEE Communication Delivery Time Performance Requirements for Electric Power Substation Automation."	2017 – 2019 WebEx collaboration meetings on demand Three face-to-face meetings per year	Waiting on PAR approval by IEEE SA.
IEC 61850-90-13	IEC TC 57	Unknown	Deterministic network technologies to guarantee bounded latency, low bounded jitter, and low packet loss.	TBD	Under discussion

3.2 Study committee activities

Table 3-2 includes a description of several active study committee activities that potentially will contribute to the utility's telecom migration strategy. Only WG D2.38 and D2.40WS3 are scheduled to complete in 2017. The others working groups are just starting.

WG B5.63 scope includes remote access to PACS for asset management including constraints and cybersecurity issues, and cloud-based PACS asset management and services based on results from WG D2.38. Depending on how this project is executed, the recommendations could be very relevant to the telecom initiative and should be assessed for impact.

WG D2.38's technical brochure is in the final stage of editing and review. Included in their technical brochure are recommendations for managing cloud-based services. These recommendations are very relevant to a utility's telecom migration strategy, and should be assessed for impact. Because D2.38's technical brochure does not address telecom operations directly; analysis is needed to assess the impact on telecom services.

More to the point, WG D2.43 is developing a technical brochure "Enabling SDN for electric power utilities' telecom applications." WG D2.43 will leverage two technical brochures developed by SC D2.

TB 588:July 2014 – "Operation and maintenance of telecom networks and associated information systems in electrical power."

TB 461:April 2011 – "Telecommunication service provisioning and deliver in the electric power utility."

The expectation is that this work should be very relevant to the utility's telecom migration strategy. As preliminary data becomes available, it should be assessed for impact on the telecom operations, and assessment findings should be summarized for D2.43's work. This will maximize the benefit of their work to the utility.

IEC TC57 is considering a proposal to develop IEC 61850-90-13 that addresses deterministic network technologies. The motivation for this proposal is to guarantee bounded latency, low bounded jitter, and low packet loss. Not stated in the proposal is the benefit of inherent cybersecurity protection. If the proposal is accepted their product should be very applicable and relevant to the telecom initiative. As drafts become available, the impact on the telecom operations should be assessed and comments provided to the working group to improve the product.

Table 3-2
Study Committee Activities

ActivityID	Sponsor	Chair Person	Description/Scope	Period of Performance	Status
CIGRE WG B5.63	SC B5: Protection and Control	Massimo Petrini	Protection, Automation and Control System (PACS) Asset Management	2017-2020	Not started
CIGRE WG D2.38	SC D2: Information Systems and Telecommunications	Dennis Holstein	Framework for utility operators to manage the response to a cyber-initiated threat to their critical infrastructure	2015-2017	In final edit and review
CIGRE WG D2.40WS3	SC D2: Information Systems and Telecommunications	Maik Seewald	Remote security service requirement objectives	2015-2017	In final edit
CIGRE WG D2.43	SC D2: Information Systems and Telecommunications	Victor Tan	Enabling software-defined networking for electric power utilities' telecom applications	2017-2020	First meeting in January 2017 Four work streams 1. Technical background 2. Utility telecom use cases 3. Case studies 4. Survey and analysis

3.3 Summary of open literature research

Applying a combined system analysis and operational analysis, the open literature research can be distilled into a preliminary checklist of recommendations for tailoring the telecom migration strategy. This list should be refined to reflect additional discovery of data and feedback from the utility telecom advisors.

- The utility should compile a complete inventory of telecom services to manage its migration to SDN/NFV services.
- Organizational units responsible for management of proposed SDN/NFV services should ensure that those services have been subjected to an approved risk assessment.
- Organizational units responsible for management of proposed SDN/NFV services should ensure they have effective control over stored or transmitted information. For example, control mechanisms, probably in contract clauses, must provide the capability to permit access to SDN/NFV service provider's facilities, operation, documentation, and databases.
- Organizational units responsible for management of proposed SDN/NFV services should ensure those services conform with the utility's policies, procedures, and organizational directives. It is the utility's responsibility to ensure their policies, procedures, and organizational directives comply with local laws and regulations; specifically, those laws and regulations governing protection of privacy information during transit and storage.

Section 4: Relevance to Utility Telecom Operations

This clause summarizes the relevance of SDN/NFV technologies to utility telecom operations. Table 4-1 shows a preliminary assessment of relevance for activity. When known, or clearly understood, benefits, concerns, and applicability are addressed. Applicability is assessed in terms of limited or unknown, possible – certain aspects could be applied, likely – identified utility telecom application, and very – expected to have major impact on utility telecom applications.

The last column summarizes the recommended action that utilities should consider to further qualify and assess the relevance to telecom operations. When there are significant unknowns, the recommended action is also uncertain and marked "to be defined (TBD)."

Table 4-1
Relevance to utility's telecom operations

ActivityID	Benefits	Concerns	Applicability	Qualification/Assessment
IEEE P1915.1	P1915.21 will establish SDN/NFV architecture options that can be tailored to meet utility telecom constraints.	P1915.1 requires utility's telecom use cases defined by others.	P1915.1 hybrid architecture option is very relevant for selective telecom application described in use cases.	Need to assess the impact of P1915.1 hybrid architecture requirements to ensure they align with telecom constraints. Early feedback through P1915.1 subject matter experts (SMEs) is critical.
IEEE P1916.1	P1916.21 will establish SDN/NFV performance options that can be tailored to meet utility's telecom constraints.	P1916.1 requires utility's telecom use cases defined by others.	P1916.1 hybrid architecture performance options are very relevant for selective telecom application described in use cases.	Need to assess the impact of P1916.1 hybrid performance requirements to ensure they align with telecom constraints. Early feedback through P1916.1 subject matter experts (SMEs) is critical.
IEEE P1917.1	P1917.21 will establish SDN/NFV reliability options that can be tailored to meet utility's telecom constraints.	P1917.1 requires utility's telecom use cases defined by others.	P1917.1 hybrid architecture reliability options are very relevant for selective telecom application described in use cases.	Need to assess the impact of P1915.1 hybrid reliability requirements to ensure they align with telecom constraints. Early feedback through P1917.1 subject matter experts (SMEs) is critical.
IEEE P1921.1	Unknown	It is not clear if there is a relationship between bootstrap requirements and telecom constraints.	Unknown	Need to monitor this activity to determine if there is a relationship between bootstrap requirements and telecom constraints.
IEEE P1926.1	Unknown	Unknown	Unknown	TBD

Table 4-1 (continued)
Relevance to utility's telecom operations

ActivityID	Benefits	Concerns	Applicability	Qualification/Assessment
IEEE P1927.1	Unknown	Unknown	Unknown	TBD
IEEE P2303	P2303 is will establish adaptive management options for SDN/NFV environments that can be tailored to meet utility's telecom constraints	P2303 requires utility's telecom use cases defined by others to associate the adaptive management options to requirements for telecommunications	Adaptive management requirements should be very relevant to the bandwidth required for selective telecom applications.	Need to assess the impact of P2303 adaptive management requirements to ensure they align with telecom constraints. Early feedback through P2303 subject matter experts (SMEs) is critical.
IEEE PS TF P11	PS TF P11 will develop a transition strategy to leverage SDN/NFV services that can be tailored to meet utility's telecom constraints.	PS TF P11 needs to complete their survey of utility requirements by the 3rd quarter of 2017 to prioritize utility's telecom applications that are now using or in the near-future will use SDN/NFV services.	Prioritizing telecom applications using SDN/NFV services is very relevant for selective telecom applications described in use cases.	Need to assess the impact of PS TF P11's survey and use cases to ensure they align with telecom constraints. This assessment and early feedback through SMEs is critical.
IEEE PSRC WG H41	WG H41 will update IEEE 1646-2004 to reflect current technologies including communication delivery time performance requirements for utilities using or planning to use SND/NFV services.	WG H41 is waiting on IEEE/SA approval of their PAR. When approved, the first meeting will be scheduled in May 2017 to reach a consensus for including SDN/NFV service communication delivery times.	Use cases describing SDN/NFV service communication delivery times is very relevant for selective telecom applications.	Need to assess the impact of WG H41 recommendations and use cases to ensure they align with telecom constraints. This assessment and early feedback through SMEs is critical.
IEC 61850-90-13	Unknown	Unknown	Unknown	TBD

Table 4-1 (continued)
Relevance to utility's telecom operations

ActivityID	Benefits	Concerns	Applicability	Qualification/Assessment
CIGRE WG B5.63	WG B5.63 will develop recommendations for PACS asset management including the management of those assets using SDN/NFV services.	Although B5.63 work has been authorized, they have yet to hold their first meeting – probably a WebEx meeting. The first face-to-face meeting opportunity is September 2017 in New Zealand.	Unknown	TBD
CIGRE WG D2.38	WG D2.38 is in the final stage of developing their technical brochure to manage the response to cyber-initiated threats. Included is a discussion of SDN/NFV services.	Telecom applications are not directly addressed. More analysis is required to map the framework to telecom applications and determine the impact on those applications.	Without additional analysis, the relevance to selective telecom applications is limited.	TBD
CIGRE WG D2.40WS3	WG D2.40WS3 is in the final stage of developing their technical brochure to identify remote security service requirements.	Telecom applications are not directly addressed. More analysis is required to map the framework to telecom applications and determine the impact on those applications.	Without additional analysis, the relevance to selective telecom applications is limited.	TBD
CIGRE WG D2.43	WG D2.43 will develop a technical brochure to recommend SDN for utility telecom applications.	WG D2.43 first meeting (via WebEx) was in January 2017. It is uncertain how quickly they will generate reviewable data.	Use cases describing SDN services should be very relevant to selective telecom applications.	Need to assess the impact of WG D2.43 recommendations and use cases to ensure they align with telecom constraints. This assessment and early feedback through SMEs is critical.

Section 5: Future Plans

As shown in the 2016 initial study, there is a significant effort underway in standards activity and study committee activity to address the secure use of SDN/NFV services. Standard developers are badly in need of use cases to ensure their specifications are implementable and address the concerns of the clients for SDN/NFV services. This is particularly true for electric power utility telecom applications. The standards developers listed in this technical update report have reached out to CIGRE study committees and to the Power Engineering Society to help develop the use cases for electric power applications. Those organization have responded by commissioning working groups to develop surveys to prioritize telecom applications of interest and to provide use case examples.

Thus, plans need to include active involvement in both the standards development and study committee activities to ensure they align with telecom operational constraints. This assessment and early feedback through participation is critical. To improve the development of a migration strategy, future work should focus on four primary areas.

1. Benefits derived from SDN/NFV telecom operations with emphasis on selected telecom applications. Focus on two areas:
   i) Prioritize based on value to the utility's telecom operation.
   ii) Identify standards that can be referenced in utility procurement specifications.
2. Technical issues that must be addressed in the telecom migration strategy that can be tailored for utility 5- and 10-year roll-out plans. Focus on two issues:
   i) Maturity of technical SDN/NFV solutions.
   ii) Multi-vendor SDN/NFV solution interoperability.
3. Utility expertise required to deploy, operate, and maintain secure SDN/NFV operations.
4. Requirements that should be included, with some tailoring, in the service agreements with the providers of SDN/NFV services.

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